

WHATEVER GAVE YOU THAT IDEA? FALSE MEMORIES FOLLOWING EQUIVALENCE  
TRAINING: A BEHAVIORAL ACCOUNT OF THE MISINFORMATION EFFECT

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The misinformation effect is a term used in the cognitive psychological literature to describe both experimental and real-world instances in which misleading information is incorporated into an account of an historical event. In many real-world situations, it is not possible to identify a distinct source of misinformation, and it appears that the witness may have inferred a false memory by integrating information from a variety of sources. In a stimulus equivalence task, a small number of trained relations between some members of a class of arbitrary stimuli result in a large number of untrained, or emergent relations, between all members of the class. Misleading information was introduced into a simple memory task between a learning phase and a recognition test by means of a match-to-sample stimulus equivalence task that included both stimuli from the original learning task and novel stimuli. At the recognition test, participants given equivalence training were more likely to misidentify patterns than those who were not given such training. The misinformation effect was distinct from the effects of prior stimulus exposure, or partial stimulus control. In summary, stimulus equivalence processes may underlie some real-world manifestations of the misinformation effect.

*Key words:* stimulus equivalence, derived relations, false memory, memory, misinformation effect, match to sample, humans

Memory errors have been the subject of considerable research in the cognitive literature over the last 40 years. This research has focused on both basic (e.g., examination of normal memory processes) and applied (e.g., inaccuracy of eye-witness memory) topics. Recently, there have been a number of studies that have tried to investigate traditional cognitive-psychological phenomena in terms of behavior-analytic processes (Guinther & Dougher, 2010; Harper & Garry, 2000; Meeter, Shohamy, & Myers, 2009).

One potential behavioral analog of processes studied in the cognitive literature that are thought to contribute to memory errors may be the development of emergent relations among stimuli such as those participating in an equivalence class. Typically, a stimulus may gain a function either by correlation temporally and spatially with another stimulus which has that function (Rehfeldt & Hayes, 1998), or by stimulus generalization based on some

physical property shared by the two stimuli. An abstract stimulus may also acquire the function of a second stimulus through a common relationship with a mediating stimulus even though they may not have been temporally or spatially correlated. Stimuli which share a common function participate in a functional equivalence class; further, stimuli which are substitutable within a specified context participate in a stimulus equivalence class (Dougher, 1998; Sidman, 1994).

Sidman (1994) demonstrated stimulus equivalence using match-to-sample (MTS) training, and he proposed that stimulus equivalence was an operant behavior, and that stimulus equivalence classes could be defined using the terms *reflexivity*, or *identity matching*, *symmetry*, and *transitivity* from mathematical set theory, although the analogy is not perfect (see Tonneau, 2001). Symmetry occurs when after training a person to select stimulus B in the presence of stimulus A (denoted as AB), the person will select stimulus A in the presence of B (denoted as BA) without further training. Transitivity occurs when after the relations AB and BC are trained, the AC relation emerges. New items added to a stimulus equivalence class need only be related to one other existing item of the class (e.g., CD) in order for emergent symmetry, transitivity and reflexivity to be observed between the added

The study described in this paper was developed from studies conducted for Danna Challies' Ph.D. thesis. We would like to thank two anonymous reviewers for their insightful comments and suggestions on an earlier version of this manuscript.

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doi: 10.1901/jeab.2011.96-343

stimulus (D) and the remaining class members (A, B and C).

Some authors refer to combined symmetry and transitivity (i.e., CA), as *equivalence* (Wirth & Chase, 2002; Yamamoto & Asano, 1995). The important feature is that the emergent relationships are not specifically trained. Sidman (1994; Sidman & Tailby, 1982) suggested that equivalence may underlie symbolic behavior and referential meaning and that tests for equivalence are also tests of semantic relations.

A further property of a stimulus equivalence class is the potential for the transfer of functions between equivalent stimuli. If a function is trained to one member of a stimulus equivalence class, without further training, other members of the equivalence class will evoke the same function (Dougher, 1998; Dougher & Markham, 1996). Both the establishment of stimulus classes and the transfer of function between class members are probably heavily influenced by contextual features (Dougher, Perkins, Greenway, Koons, & Chiasson, 2002; Meehan & Fields, 1995; Randell & Remington, 2006; Rehfeldt, 2003).

Guinther and Dougher (2010) investigated whether such derived relations could be seen as analogous to semantics (meaning) in the cognitive literature and thus have similar effects on memory. In the classic cognitive-psychological Deese-Roediger-McDermott (DRM) procedure (Roediger & McDermott, 1995), participants are asked to study lists of semantically related words (e.g. words with related meaning such as "pillow", "bed", "rest"). Then, participants are given a test in which they are asked to recall the list words; often, they falsely recall words that are semantically related to the studied word list (e.g., "sleep") and the likelihood of a false recall is correlated with increased semantic relatedness. This phenomenon is not restricted to verbal stimuli: Participants who view a sequence of images consistent with a familiar script (e.g., making a sandwich) are more likely to falsely recognize images which were not included in the original to-be-memorized set, but which are consistent with the script (Gerrie, Belcher, & Garry, 2006; Hannigan & Tippens Reinitz, 2001; Jenkins, Wald, & Pittenger, 1986).

In their DRIFT (derived relational intrusions following training) procedure, Guinther and Dougher (2010) created an analogue of

semantic relatedness by using match-to-sample training to establish equivalence classes between groups of randomly selected words. In addition, Guinther and Dougher ensured that each of the targeted words in a critical set was also correlated temporally and spatially with a distracter word from another set. Thus, each of the target words was related through equivalence (hypothetically analogous to semantic relations) to one nontarget word, and each target word was associatively related to a second nontarget word through temporal and spatial contiguity in the absence of reinforcement. Participants were then requested to memorize 12 of the 24 original target words, followed by recall and recognition tests. In the recognition test, both target and nontarget words were presented. Participants were significantly more likely to recall incorrectly or recognize nontarget words related to target words through derived relations than they were to recall incorrectly or recognize nontarget words related through temporal/spatial correlation or unrelated words presented as distracters during the training procedure.

Guinther and Dougher (2010) argued that having established stimulus equivalence by training the relation "MEANS THE SAME THING," when they then trained a new function, "REMEMBER THIS," to half of the target stimuli, functional transfer resulted in other stimuli in the equivalence set also entering into the "REMEMBER THIS" relation. Memory intrusions were thus a natural result of this transfer of function between stimuli. This transfer of function was more important in determining intrusions than was spatial and temporal association. The present study joins this emerging field of behavioral research by investigating whether derived relations might also contribute to a related false-memory phenomenon, the misinformation effect.

#### *The Misinformation Effect in the Cognitive Literature*

The phenomenon of changes to reported memory as a result of subsequent misinformation, termed the *misinformation effect*, has been well demonstrated. Since the mid-70s, a plethora of research has demonstrated that postevent misinformation may change reported details of an event that an individual has witnessed or even cause individuals to report

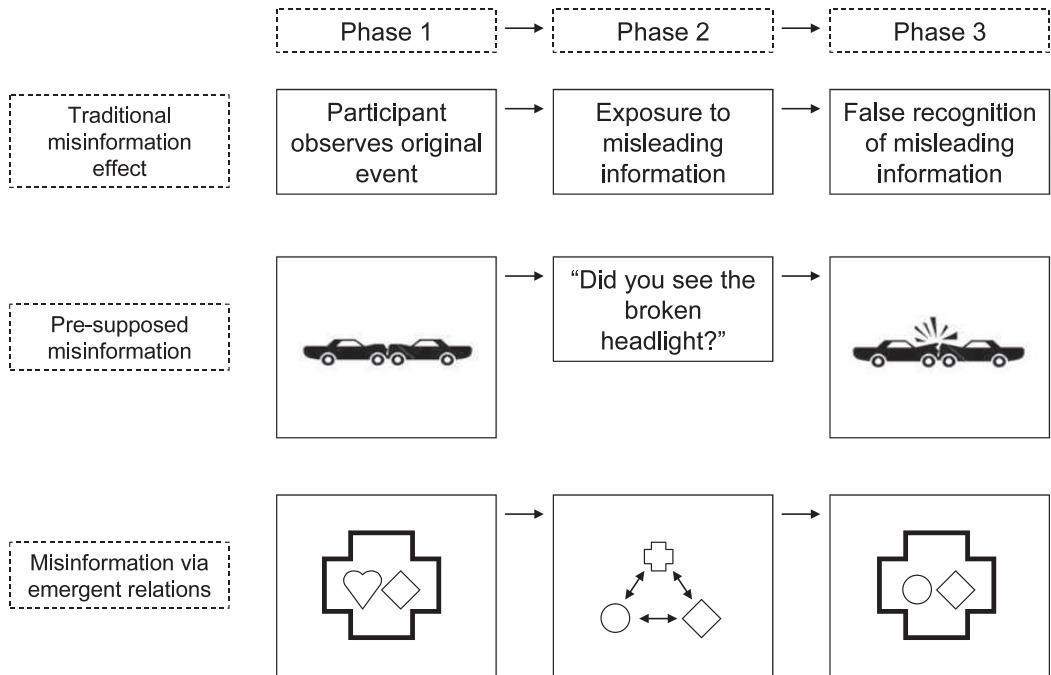


Fig. 1. Overview of the procedure. The rows compare two types of cognitive psychological misinformation studies, typically in three phases, and the present behavioral study. The left column shows the target event or stimulus to be remembered, the second column shows the source of misinformation, and the right column shows the event or stimulus that is erroneously recognized as the target.

people or objects that were never experienced (e.g. Allen & Lindsay, 1998; Belli, 1989; Chandler, Gargano, & Holt, 2001; Henkel, Franklin, & Johnson, 2000; Lindsay, 1990; Lindsay, Allen, Chan, & Dahl, 2004; Lindsay, Hagen, Wade, & Garry, 2004; Loftus, 1975, 1979; Loftus & Hoffman, 1989; Loftus, Miller, & Burns, 1978; Loftus & Palmer, 1974; Lyle & Johnson, 2006; Marche, Brainerd, & Reyna, 2010; Mitchell & Zaragoza, 1996, 2001; Okado & Stark, 2005; Skagerberg & Wright, 2008; Stark, Okado, & Loftus, 2010; Sutherland & Hayne, 2001; Wright & Loftus, 1998; Wright, Self, & Justice, 2000).

The paradigmatic misinformation study (Loftus et al., 1978) consists of three phases (see top panel of Figure 1). In the first phase, an eyewitness is exposed to an event. In the second phase, information that contradicts factual detail of the observed event is then given to the eyewitness. This information is often in the form of questions ostensibly about some other facet of the event (e.g. Sutherland & Hayne, 2001), or a narrative purporting to summarize the event (e.g. Searcy, Bartlett, &

Memon, 2000). In the third phase, when the eyewitnesses are asked to recall or recognize the original event, their reports often integrate the misinformation to which they have been exposed.

#### *Indirect Misinformation*

While the Loftus et al. (1978) procedure may reliably produce inaccurate performance on recall and recognition tests, it is not clear that it captures what happens in many real-world cases. In many real-world occasions where a witness has incorporated misinformation into his or her testimony, there is no indication that the witness was misled by information provided after the event (Gross, Jacoby, Matheson, Montgomery, & Patil, 2005). It is, however, possible that information has been inferred, or acquired indirectly, from a variety of sources rather than explicitly provided. This indirect information may be incorporated into the witness's report of the event. Studies of the effects of postevent misinformation generally focus on providing misinformation that specifically contradicts

details of the original event. However, a few studies have shown that participants' reports may also be influenced by indirect or inferred misinformation (Loftus, 1975; Loftus & Palmer, 1974), described by the researchers as "presupposition." For example, Loftus and Palmer provided subjects with misinformation by manipulating the verbs used to describe an accident between two vehicles. Verbs presupposing a more violent accident resulted in eyewitnesses more likely to report having seen broken glass, even though the original film of the accident did not show any broken glass.

A related study (Loftus & Zanni, 1975) asked one question presupposing the existence of a target object, "Did you see *the* broken headlight?" These participants were more likely to falsely report having seen a broken headlight than participants exposed to a nonpresumptive question, "Did you see *a* broken headlight?" It may be argued that these presupposition variations of the misinformation paradigm insert a false element into an original memory by presenting a semantic equivalent to the participants. The question, "Did you see *the* broken headlight?" carries with it the semantic construal "there was a broken headlight present during the original event." The false element is incorporated into the participant's account of the event through semantic relations.

#### *Source Monitoring*

One cognitive account of the misinformation effect is that memory errors are due to *source monitoring* errors (Lindsay, 1990; Lindsay, Allen, et al., 2004; Mitchell & Johnson, 2000). As new information is encountered, it is integrated into a person's knowledge of an original event via semantic relations. In this account, if the semantic relations between new and existing information are strong, and the association between new information and its source is weak, the new information (misinformation) is ascribed to the same source as the original event.

From a behavioral perspective, stimulus equivalence can account for the misinformation effect. First, equivalence provides a vehicle by which a new function or response may join a preexisting behavioral repertoire without explicit training or direct contact between all elements. Second, consideration of the interplay between context and class

accounts for the effects of source monitoring. Equivalence classes are contextually controlled; without it, equivalence class expansion would rapidly render all stimuli part of a single class. It is possible that in the real-world, equivalence class members themselves would form a part of the context which controls responding to their class.

In some instances, the addition of new stimulus-class members may be context-dependent such that two overlapping stimulus classes are created. In other words, given the original context, the original class may be retained, and given a new context, the class is composed of the original stimuli and the new stimuli. A situation in which the two contexts are not readily discriminable may be analogous to the notion of a source-monitoring error.

If derived relations are a behavioral analogue of semantic relatedness (as suggested by Guinther & Dougher, 2010), it should be possible to replicate the misinformation effect in behavior analytic research using the equivalence paradigm. This idea is consistent with Guinther and Dougher's results, but there are also some aspects of the misinformation effect that need further consideration to confirm the potential role of emergent relations in this type of recognition error. The present study investigated whether recognition errors could be indirectly produced by substituting component stimuli of an originally learned compound stimulus (target pattern) with novel component stimuli that had been linked to the original component stimuli of the target pattern in the relation "BELONGS WITH" via MTS training (see Figure 1).

In Phase 1 of the current procedure, the to-be-remembered objects were presented together as spatial arrays or compound stimuli (the target patterns). In Phase 2, for participants in the experimental group, MTS training was used to establish stimulus equivalence and the relation "BELONGS WITH" among the members of the training sets and including one new object (for each set) not presented in Phase 1. In Phase 3, participants were given a recognition test in which stimulus patterns were: (1) those trained in Phase 1 (i.e., targets in the cognitive literature); (2) made up of objects from Phases 1 and 2 (i.e., lures in the cognitive literature); and (3) made up of novel objects (i.e., foils in the cognitive literature).

In line with the cognitive literature on the misinformation effect, it was expected that participants who passed equivalence tests in Phase 2 would respond to both the target and lure patterns, but not the foil patterns. By contrast, participants in the control group were expected to respond to the target patterns, but not the lure or foil patterns.

Through this research, we are proposing a potential behavioral account for some instances of the misinformation effect. That is, we propose emergent relations as a mechanism whereby a false element may come to be reported as an integral part of an original event.

## METHOD

### *Participants*

Fifty-one introductory psychology students participated. The only exclusion criterion was color-blindness. Participants earned credits towards the research component of the course. Twenty-four participants were randomly assigned to a control group and 27 to an experimental group. Of this group, 3 were removed from the final analysis: 1 did not show for the second session, and 2 failed to complete the MTS task within the time allotted.

### *Apparatus*

The stimuli were presented on a computer monitor by means of a Macromedia Authorware 6 interactive training program. The program display was 22 cm wide by 15 cm high on a 35-cm VGA monitor. Participants were seated 30-70 cm from the monitor (primarily dependent on personal preference). Participants responded to sample stimuli by using a mouse to move the on-screen cursor either to the stimuli or to a virtual button and clicking the left button on the mouse. Participant responses and the time spent on the task (exclusive of reading instruction screens) were recorded and saved to a text document at the completion of each phase of the study.

The stimuli were colored shapes and three letters. Nine of the colored shapes were arranged into three target patterns and were used in Phase 1. Each pattern consisted of a large colored shape, with two smaller colored shapes located within the contour of the larger shape as shown in the top row of Figure 2.

Fifteen colored shapes were arranged into five distractor patterns for use in the test component of the phase.

For Phase 2, the three letters, A, B, and C were presented in Comic Sans MS font 35 mm high, and nine colored shapes were arranged into three 4-member classes as shown in Figure 3. Note two colored shapes in each class were identical to two components of a target pattern used in Phase 1. A third shape in each set (B1, B2, or B3) was the same shape as the remaining component (one of the smaller, internal, colored shapes) of the target pattern, but was a different color.

In Phase 3, there were three types of stimulus patterns: (1) the same three target patterns from Phase 1; (2) three lure patterns each composed of the colored-shape stimuli from one of the equivalence classes trained in Phase 2 (see second row of Figure 2); and (3) six foil patterns made up of a mixture of both previously seen and novel color/shape combinations (see third row of Figure 2).

### *Procedure*

The experiment was conducted in three phases over two sessions held on the same day (see Figure 1); the first session ran for a total of 30 min including the time taken to give instructions, while the second session ran for a total of 60 min including instructions and debriefing times. There was a delay of 90 min between sessions. During Session 1, participants carried out a learning task. During Session 2, participants completed a stimulus equivalence task (experimental group) or vigilance task (control group), followed by a recognition test of patterns learned during the first session.

*Participant preparation.* To be consistent with the standard misinformation studies, participants were misled as to the purpose of the experiment. At the start of the first session, participants were informed that they were participating in an experiment comparing "long-term memory" with "working memory" for similar stimuli. The memorization task and the recognition test were ostensibly the long-term memory task, while the stimulus equivalence training (or vigilance task for the control group) was described as a test of working memory. The instructions for all participants at the start of the first session were:

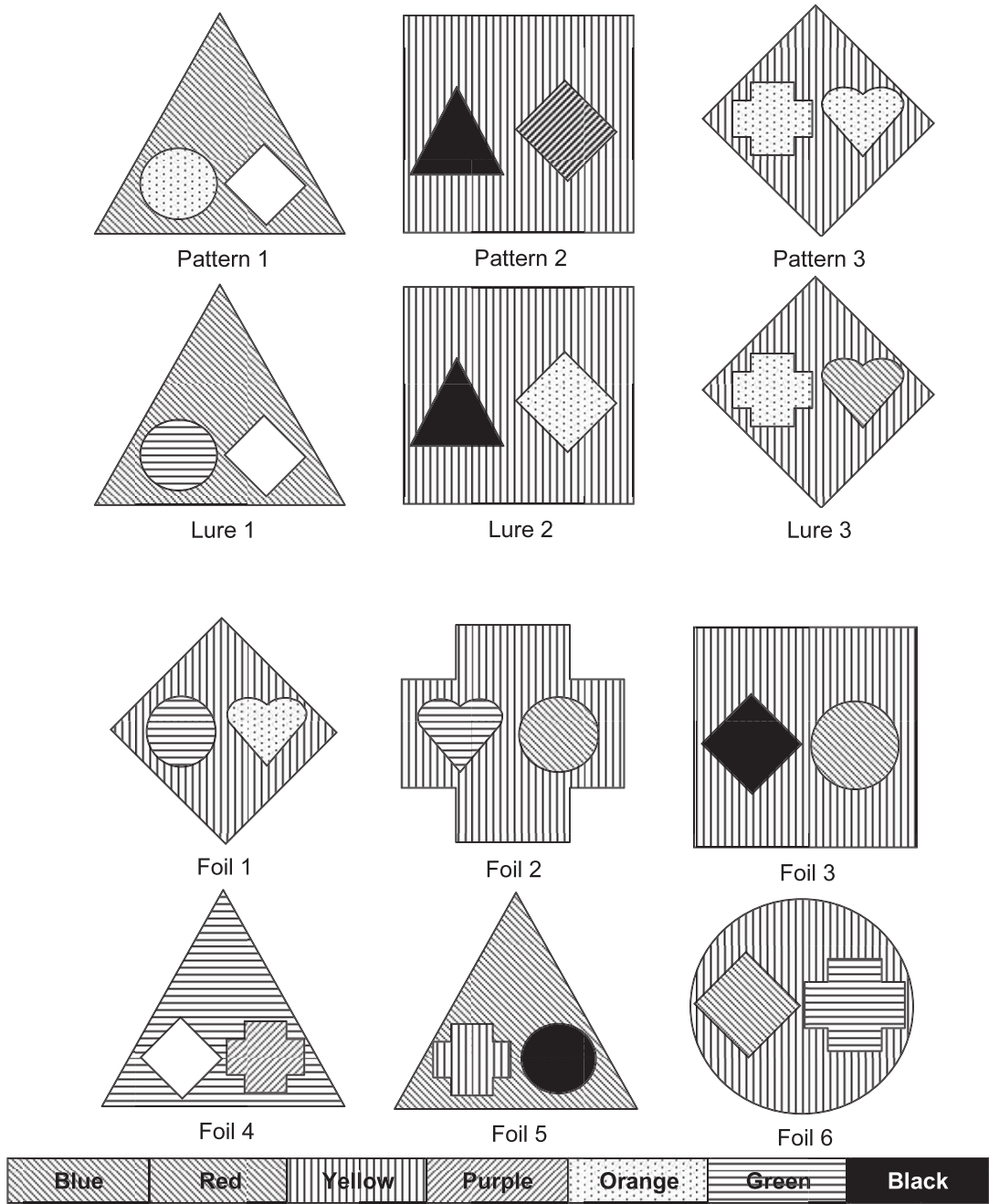


Fig. 2. First line shows target stimuli for the memory task; actual height of each pattern onscreen was between 8 and 9 cm high (depending on pattern). Lure patterns are on line 2, and foils are on lines 3 and 4. Color codes are below the stimuli. All stimuli were used in the recognition test. Stimuli were presented individually and in random order.

“Today we are comparing long-term memory with working memory, to investigate whether people who are better at retaining a mental representation of an image over a period of

time are also better at continually updating their memory during a learning task. This is the first session of the long-term memory task where you will learn three patterns made up of

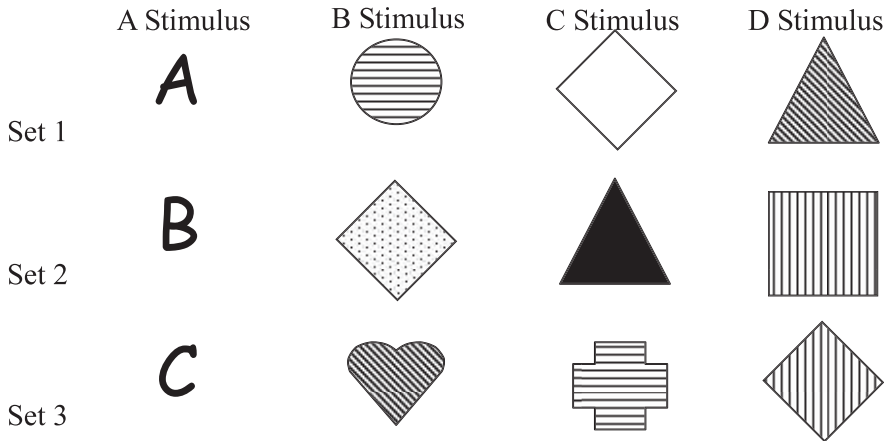


Fig. 3. Sets used for the stimulus equivalence task. Actual height of each object on screen was 3.5 to 4 cm high (depending on object).

coloured shapes. The computer will take you through a training program and test you at the end to ensure you have memorised the patterns. If you do not pass the test, the program will return you to the start of the training segment to repeat the training. You need to have memorised the patterns by the end of this session in order to qualify to come back for the second session. At the end of the second session, you will be tested on your memory for the patterns, after the working memory test.

Pay attention to both the colours and shapes in each pattern; there may be up to three different shapes of each colour, or three different colours that have the same shape, in different patterns."

Feedback at the conclusion of the study confirmed that the deception was successful. Participants were also advised that they were free to withdraw from the study at any time and completed written consent forms before starting Phase 1.

#### *Phase 1—Learning Task*

For the initial learning task, participants were exposed to, and interacted with three patterns each composed of three colored shapes (see Figure 2, top row). The task consisted of four components: (1) passive exposure; (2) a constructed response task; (3) self-paced exposure; and (4) an exit test.

For the initial passive exposure phase, participants were exposed to each pattern for 4 s four times sequentially. Above each pattern was the sentence "Study the pattern careful-

ly," and below each pattern was the label "Pattern X" where X refers to the number 1, 2 or 3.

In some cognitive studies of the misinformation effect, false recall and recognition responses have been demonstrated by both "misinformation interference"—where presentation of a novel stimulus prevented reporting of an original stimulus—and also "misinformation acceptance"—where the false recall/recognition response was due to the participants either forgetting some, or not attending to all, of the stimuli presented at the original event (Belli, 1989). For the present research, it was important to reduce the likelihood of the latter in order to ensure the observed effects were consequent to derived relations. This required a training program which ensured that participants attended to all aspects of the patterns, rather than having responses come under control of one or a few dimensions of the target pattern (partial stimulus control).

Constructed response tasks have been found to improve literacy skills by requiring a participant to attend to all components of the stimulus (e.g. De Rose, De Souza, & Hanna, 1996; Dube, McDonald, McIlvane, & MacKay, 1991). This technique was used here to similarly ensure participants attended to all aspects of the pattern. For this training task, participants received the on-screen instruction "please construct Pattern 'X' if all of its objects are here." They were then required to select (with a mouse click) and drag the two small

components of each pattern, from an array of colored shapes, on to the larger background shape. The array consisted of seven stimuli that differed in shape and color. If the participants selected an incorrect colored or shaped stimulus, the stimulus immediately returned to its starting position in the array. If they attempted to place the correct colored shape into the wrong position (left or right of the central axis) the object snapped into the correct position. The participants repeated the process of selecting stimuli from the array until they had placed the two correct internal colored shapes within the contour of the background shape (except for the two trials noted below). At that point, a button labeled "Continue" appeared, and clicking on it advanced the program to the next trial. There were a total of six constructed response trials, two for each pattern. For each of these trials, the stimuli available in the array included two stimuli, each the correct shape and color of one of the component stimuli of the pattern. The remaining stimuli varied across trials but included at least one stimulus that was the same color or shape as the correct stimulus and two other stimuli that were either the same color as each other but not the color of the correct stimulus or the same shape as each other but not the shape of the correct stimulus. The incorrect stimuli included in the array were different for the two trials for each pattern. In this way it was necessary for the participant to attend to both color and shape to complete the task accurately. There were two additional trials that did not include all of the correct components for a target pattern within the array. For these trials the correct response was to click a virtual button stating, "Pattern X cannot be constructed." This button was present for all constructed response trials, but responses to this button were ineffective when all components were available.

Following the constructed response task, participants were allowed to view each of the patterns for as long as they liked before completing a test. A total of eight trials were presented in the test, three patterns were the target patterns, and five patterns were distracters similar to (but not the same as) those shown in Figure 2. On each trial, one pattern was presented with two response buttons positioned directly below it. One button was

labeled "old" and the other was labeled "new." Participants were asked to select the "old" button if the pattern was one of the three training patterns and the "new" button if the pattern was not previously seen. Participants who failed to correctly classify all patterns returned to the start to re-run the entire learning program. The criterion for continued participation in the study was to accurately classify all patterns within the 30 min allotted for the first session (all participants eventually passed the memory test).

#### *Phase 2—Stimulus Equivalence Task (Experimental Group)*

*Baseline training.* Sidman's (Sidman & Tailby, 1982) match-to-sample (MTS) method was used to train three 4-member stimulus equivalence classes. Earlier work (Challies, 2005) had shown that participants had difficulty learning this type of task. To facilitate acquisition of the training relations and the emergence of equivalence, this experiment incorporated exclusion techniques for training novel stimuli (exclusion is frequently used to facilitate rapid and accurate learning in typically developing and developmentally-delayed children). The first two stimuli in each set were presented twice for 5 s each as paired associates prior to the first MTS training trials, and subsequent trials introducing new class members used familiar stimuli belonging to another class as the other two comparison stimuli. This allowed the participant to exclude the familiar distracters and correctly select the new class member (see Ferrari, de Rose, & McIlvane, 1993; Ferrari, De Rose, & McIlvane, 2008).

Additionally, Arntzen (2004) found that using a picture rather than an abstract stimulus as the first stimulus in a set facilitated the emergence of equivalence, presumably due either to familiarity with the stimuli or naming the stimuli (Horne & Lowe, 1996). For this reason, one stimulus in each set was a letter (A stimuli in Figure 3) and the remaining stimuli were the three colored shapes (B, C, and D stimuli in Figure 3). The letter stimulus was also meant to reduce the possibility that participants would find similarities between the "long-term memory" task patterns, and the "working-memory" task sets, and contribute to contextual confusion at the final recognition test through its absence (see

discussion). The stimuli designated as B in Figure 3 were novel to this phase of the experiment. Because initial Phase 2 training involved the A and B stimuli, the participants had a period of training with novel stimuli before previously encountered stimuli were introduced as the C and D stimuli. Finally, the colored shape which formed the background contour of the target pattern in Phase 1 was judged to be the most discriminable target-pattern component both because it was the largest and formed the outline contour, and was always introduced last (D stimuli in Figure 3).

At the start of this session, participants in the experimental group were told in both oral and written on-screen instructions that both the "long-term memory" and the "working memory" tests would use similar stimuli, supposedly to reduce confounds due to differing levels of familiarity with different types of stimuli. The instructions were:

"You will be working on two different computer programs in this session. The first program is the working memory test. You will be learning three sets of objects at the same time. Each set contains one letter, and three coloured objects [researcher draws a sample set 'E' on the white board with coloured markers]. Because we are comparing two different types of memory, we need to make sure that the objects we use in the two tests are reasonably similar to each other. This is because if we used totally dissimilar objects, we could introduce a 'confound' into our study—that is—we would not know whether any difference in performance was due to the different memory task, or because we used different types of objects in the different tasks.

Pay attention to both the colour and the shape of each object; both colour and shape may repeat in different combinations.

If you focus on just the colour or the shape you are likely to get confused later on in the working memory task. If you make a mistake during some trials, the program gives you a short period of retraining—you do not go back to the start every time you make a mistake.

When you have finished the working memory task, let me know and I will start the long-term memory test for you. After you have finished that, I have a short feed-back form for you to fill out, then a quick debrief and you are free to go."

Table 1 provides an overview of the training and testing sequence. Stimulus equivalence classes were trained in 10 blocks designated

Block 0 to Block 9. During Block 0, the initial stimulus pairs (A1, B1; A2, B2; A3, B3) in each class were established by means of contiguity, before beginning the match-to-sample procedure. Blocks 1 to 8 were match-to-sample trials; the sample stimulus was located in the upper half of the display panel, while three comparison stimuli (an S+ and two S−) were arranged horizontally on the lower half of the display panel. Onscreen instructions stated: "Please select the object that belongs to this set."

During *training* blocks, the position of the S+ (left, center, or right) alternated randomly, without replacement, until each S+ had been presented in each location. Each block trained one relation (e.g. A1–B1, A2–B2, and A3–B3), so a complete training block consisted of nine trials—the target relation for each set presented three times with the S+ in a different position each time. If any participants made an error during a training block, they repeated that training block until they met the 100% accuracy criterion across the nine trials comprising that block. Audible feedback indicated correct responses with a high pitched "ding" and incorrect responses with a low pitched "buzz."

For blocks *testing* symmetry or transitivity, the S+ for the relation being tested was presented once only for each set, in a position (left, center, or right) selected at random. There was no feedback supplied during testing blocks. After all test relations were presented, the participants either progressed to the next block of the program (if they had correctly selected all S+), or repeated earlier training blocks (if they had not identified all S+). Criterion for progression for all blocks was 100%.

Stimulus equivalence classes were considered established on successful completion of the stimulus equivalence MTS task. The final confirmatory test of class membership was also a MTS exercise; however, the sample stimulus was set in the centre of the screen, while nine comparison stimuli were arranged in a "u" shape lining the lower half of the display panel. Participants were asked to identify all members of each equivalence class by clicking on the stimuli (described to participants as a "set"). There was one test trial for each set.

#### *Phase 2—Vigilance Task (Control Group)*

Control group participants did not complete the stimulus equivalence program; these

Table 1  
Overview of match-to-sample stimulus equivalence task.

Block	Process	Sample Stimuli	S+	S–	Criterion for progression
0.	Introduce A–B	A1; B1 A2; B2 A3; B3			Repeat twice for 5 s each.
1.	Train A–B	A1 A2 A3	B1 B2 B3	B2, B3 B1, B3 B1, B2	Random presentation without replacement. Repeat until 100% correct on nine consecutive trials.
2.	Test symmetry B–A	B1 B2 B3	A1 A2 A3	A2, A3 A1, A3 A1, A2	Target relation for each class is presented once only, in random position (left, center, right). If any failed, retrain blocks 0 and 1 before retest.
3.	Train A–C	A1 A2 A3	C1 C2 C3	B2, B3 B1, B3 B1, B2	Random presentation without replacement. Repeat until 100% correct on nine consecutive trials.
		A1 A2 A3	C1 C2 C3	C2, C3 C1, C3 C1, C2	Random presentation without replacement. Repeat until 100% correct on nine consecutive trials.
4.	Test symmetry C–A	C1 C2 C3	A1 A2 A3	A2, A3 A1, A3 A1, A2	Target relation for each class is presented once only, in random position (left, center, right). If any failed, retrain blocks 1 and 3 before retest.
5.	Test transitivity/ equivalence B–C, C–B	B1 B2 B3 C1 C2 C3	C1 C2 C3 B1 B2 B3	C2, C3 C1, C3 C1, C2 B2, B3 B1, B3 B1, B2	Target relation for each class is presented once only, in random position (left, center, right). If any failed, retrain blocks 1 and 3 before retest.
6.	Train B–D	B1 B2 B3	D1 D2 D3	C2, C3 C1, C3 C1, C2	Random presentation without replacement. Repeat until 100% correct on nine consecutive trials.
		B1 B2 B3	D1 D2 D3	D2, D3 D1, D3 D1, D2	Random presentation without replacement. Repeat until 100% correct on nine consecutive trials.
7.	Test symmetry D–B	D1 D2 D3	B1 B2 B3	B2, B3 B1, B3 B1, B2	Target relation for each class is presented once only, in random position (left, center, right). If any failed, retrain blocks 1, 3 and 6 before retest.
8.	Test transitivity/ equivalence D–A, D–C, A–D, C–D	D1 D2 D3 D1 D2 D3 A1 A2 A3 C1 C2 C3	A1 A2 A3 C1 C2 C3 D1 D2 D3 D1 D2 D3	A2, A3 A1, A3 A1, A2 C2, C3 C1, C3 C1, C2 D2, D3 D1, D3 D1, D2 D2, D3 D1, D3 D1, D2	Target relation for each class is presented once only, in random position (left, center, right). If any failed, retrain blocks 1, 3 and 6 before retest.
9.	Identify classes	A1  A2  A3	B1, C1, D1 B2, C2, D2 B3, C3, D3	B2, C2, D2, B3, C3, D3 B1, C1, D1, B3, C3, D3 B1, C1, D1, B2, C2, D2	Final test (score is recorded). No feedback provided.

Table 2  
Percentage of "old" responses to individual patterns.

	Target 1	Target 2	Target 3	Lure 1	Lure 2	Lure3	All Foils
Experimental Group	95.83%	70.83%	83.33%	58.33%	54.17%	75.00%	8.00%
Control Group	91.67%	79.17%	95.83%	16.67%	4.17%	12.50%	1.00%

participants completed a vigilance task using the same stimuli that the experimental group had for the stimulus equivalence task test. The vigilance task was a computer program superficially similar to the equivalence task and written using the same software. The vigilance task consisted of a series of twenty 2-min blocks where the stimuli were presented individually on the screen, in random order, and at random locations, for 2 s each. At the start of the task, also described to participants as a test of working memory, participants were told in both oral and written on-screen instructions that they were working on a "long-term memory" task and a "working-memory" task as follows:

"You will be working on two different computer programs in this session. The first program is the working memory test. A series of objects and letters will be displayed on the screen. Your task is to identify a specific sequence of objects and letters and press the space bar after the LAST object in the sequence is displayed [researcher draws a sample sequence of one letter and two coloured objects on the white board]. You must disregard all objects which are not in the target sequence. The target sequence will be changed from time to time.

The objects include coloured shapes similar to those used in Session 1 which you completed earlier. This is because if we used totally dissimilar objects, we could introduce a 'confound' into our study—that is—we would not know whether any difference in performance was due to the different memory task, or because we used different types of objects in the different tasks. Pay attention to both the colour and the shape of each object; both colour and shape may repeat in different combinations.

When you have finished the working memory task, let me know and I will start the long-term memory test for you. After you have finished that, I have a short feed-back form for you to fill out, then a quick debrief and you are free to go."

At the start of each 2-min block, the participants were given the target sequence

for that block in on-screen instructions. Target sequences became increasingly complex across tasks. For example, on early trials, participants were instructed to, "Hit the space bar when you see a letter followed by a letter," while on later trials, they were instructed to, "Hit the space bar when you see a letter, followed by a red object, followed by a square."

The vigilance task exposed participants to the stimuli for a total of 40 min during the hour-long second session. An earlier series of studies using the equivalence task with four different groups of students had established that while the time in the session was typically 30 to 40 min, the mean time actually exposed to the equivalence stimuli (that is, time on-task exclusive of reading instructions and pausing between blocks) for these groups had been close to 10 min (Challies, 2005). The present vigilance task was designed to control for familiarity with the Phase 2 stimuli by ensuring that the control group had approximately the same duration of exposure to each of the stimuli. In the MTS task, four stimuli were simultaneously presented, while in the vigilance task the stimuli were presented individually. Forty min were used for the vigilance task to ensure that each participant observed stimuli for approximately the same amount of time as participants who completed the MTS task.

### *Phase 3—Recognition Test*

The recognition test presented individual stimuli (target patterns, lures and foils as shown in Figure 2) sequentially in random order. Three trials were the *target patterns*, the three original patterns learned in Phase 1. A further three trials were *lures*, patterns similar to the targets but composed of the stimuli from Phase 2. The remaining six trials were *foils*, patterns which contained both novel stimuli and at least one stimulus from the target patterns.

Participants had been briefed that this phase was the "long-term memory" test of

the original patterns they had memorized in their earlier session; they were instructed to view the patterns, identify old patterns from Phase 1 by selecting the “Old” button, and identify new patterns by selecting the “New” button. Note that this was the same response method used in the exit test for Phase 1, so participants were familiar with it. On-screen instructions stated:

You will be shown a series of patterns, some of which you memorized during the first session (Memory Task I). Others will be new. Below the pattern you will see two buttons labeled ‘Old’ and ‘New.’ For each pattern, click on the ‘Old’ button if it is one of the three you have memorized from your first session. Click on the ‘New’ button if the pattern is not one of the original three from the first session.

Following Phase 3, participants were given an oral debrief which began by asking, “Did you notice any links or similarities between the Working Memory task, and the final Memory test of the photos? If yes, what were any linkages or similarities between the two tasks?” The experimenter noted their answers and continued the oral debrief by outlining the actual objectives of the study and the need for the original deception.

## RESULTS

Of the 26 experimental-group participants who returned for the second session, 24 completed the stimulus equivalence task within the 60 min allocated for the task in total (including instructions). The following analysis excludes the nonfinishers ( $n=2$ ). All members of the control group returned for the second session ( $n=24$ ) and no adjustment of group size was required to facilitate statistical analysis. The success of the deception was confirmed by oral feedback: None of the participants identified similarities between the sets learned in Phase 2 and the patterns used in Phase 1, other than use of the same *type* of stimuli (colored shapes). Moreover, none suspected that the Phase 2 task might interfere with the Phase 1 task.

### *Responses to Target Patterns, Lures, and Foils*

The percentage of “old” responses to the three types of stimuli is presented in Figure 4. This figure shows that the percentage of “old” responses to the target (83% and 89%) and foil

(8% and 1%) patterns was similar across the experimental and control groups, respectively. That is, participants generally correctly identified the target patterns as old, and correctly identified the foil patterns as new. This figure also shows there was a clear difference between groups in their responses to the lure patterns. The experimental group tended to incorrectly identify lures as old (63% of trials), albeit less frequently than the targets were identified as old. The control group, however, responded to lures as they did to the foils (“old” was the response on 11% of trials). That is, whereas experimental participants tended to identify the lure patterns as old, the control participants tended to correctly identify them as new. Responses to individual patterns and lures are detailed in Table 2.

A  $2 \times 3$  mixed-design ANOVA revealed a significant main effect of group,  $F(1, 46) = 34.83$ ,  $p < .001$ , partial  $\eta^2 = .431$ , and a significant main effect of pattern type,  $F(1.53, 70.46) = 223.40$ ,  $p < .001$ , partial  $\eta^2 = .829$ . There was a significant interaction effect between group and pattern type,  $F(1.53, 70.46) = 29.40$ ,  $p < .001$ , partial  $\eta^2 = .39$ . Where Mauchly’s test indicated that the assumption of sphericity had been violated, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity.

Post hoc analyses using pairwise comparisons of responses to patterns within groups and a Bonferroni correction for multiple tests indicated that, for the control group, there was no significant difference between responses to the foil and lure patterns (1% and 8% respectively), but that there were significantly more “old” responses to the target patterns (89%) than to both foil and lure patterns. For the experimental group, there were significant differences between all pattern types, meaning that there were more “old” responses to targets than both foils and lures but also more “old” responses to lures than to foils.

This pattern of responding can also be observed at the individual subject level. Every participant in the experimental group responded “old” to at least one of the lure patterns and 58% responded “old” to two or more lures (see Appendix A). By contrast, 71% of participants in the control group did not respond “old” to any lure and only 1 participant responded “old” to more than one lure (see Appendix B).

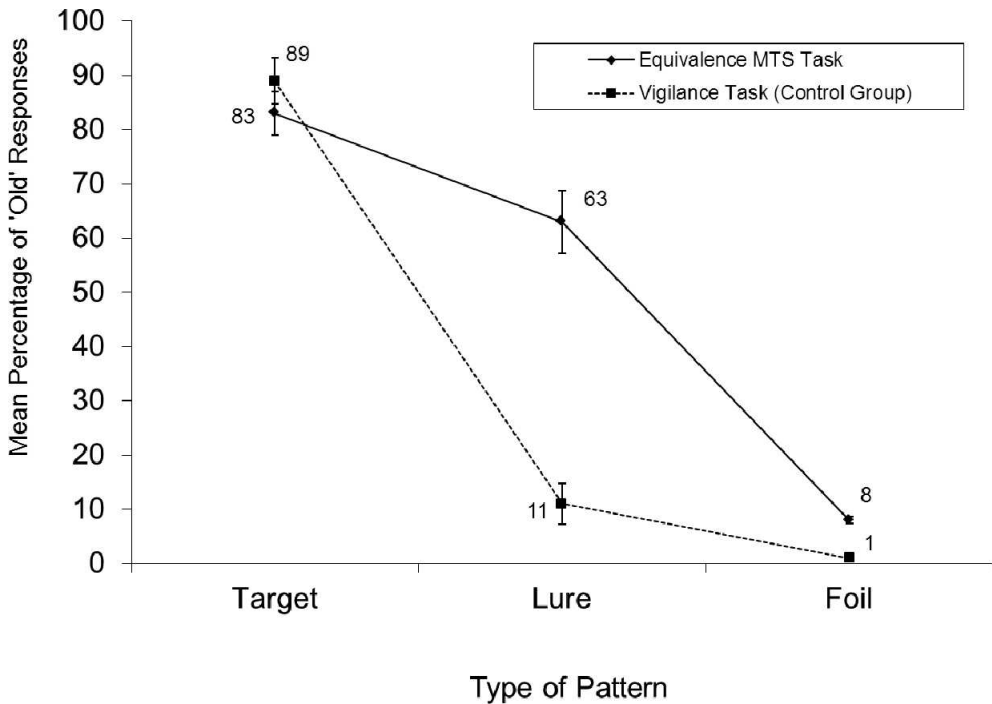


Fig. 4. Mean percentage of "old" responses to each type of pattern for the control (vigilance task) and experimental (MTS task) groups in the recognition test. "Old" responses to target patterns are correct identifications, but "old" responses to lures and foil patterns are false recognitions. Error bars indicate standard error.

Further analyses were carried out to ensure that the differences between the experimental and control groups were due to equivalence training, and not due to differences in initial recall of the target patterns following the learning task, or differences in the duration of exposure to the Phase 2 stimuli in the experimental context. Additionally, the influence of acquisition rate in the MTS task was considered.

#### *Initial Recall Performance*

There were no significant differences between the two groups in performance on the Phase 1 task. All participants successfully completed the pattern recognition task within the 30 minutes allotted. Four control and 5 experimental participants required, and successfully completed, retraining within that time. There were no differences in task completion time between the control group ( $M = 19.50$  min,  $SD = 4.46$ ), and the experimental group ( $M = 18.28$  min,  $SD = 5.41$ ),  $t(46) = .37$ , n.s.

#### *Duration of Exposure to Phase 2 Stimuli*

The vigilance task appeared to adequately control for mean duration of exposure to the Phase 2 stimuli. The control group was exposed to the 12 stimuli in random sequence for 40 min; a mean time of 3 min 20 s for each stimulus. The mean time spent on-task (with the Phase 2 stimuli on screen) for the experimental group was 9 min 55 s in total ( $SD = 4$  min 37 s). Only four of the stimuli were on screen at any one time during the MTS task, resulting in a mean exposure of 3 min 18 s for any given stimulus.

In addition, there were no effects of exposure time within the experimental group. The time taken to complete the MTS task varied considerably across participants; the fastest participant spent 4 min 1 s on-task, while the slowest participant spent 20 min 17 s on-task. Although there was a wide variation in the time taken to complete the MTS task, there was no relation between the time it took to complete the task and the number of "old" responses to the lures ( $R^2 = .0045$ ).

### *Match-to-Sample Task Acquisition*

One explanation for the observed wide variation in the duration of time needed to acquire the stimulus equivalence task is that participants who failed a testing block repeated baseline training and were then retested (see Table 1). Time to complete MTS training and testing was moderately correlated with the number of test phases required to reach criterion ( $R^2 = .69$ ). Most participants had little difficulty with B–A and C–A symmetry, but about half the participants needed retraining to acquire B–C/C–B transitivity and D–B symmetry. Only 3 participants acquired A–D/D–A and C–D/D–C transitivity without baseline retraining. Only 1 participant completed the entire task without retraining on any block. At the conclusion of the MTS training, the participants were asked to select all the members of each set. Only 3 participants made one error each (out of nine responses). A summary of individual data for the experimental group is in Appendix A.

### DISCUSSION

The results supported the hypothesis that stimulus equivalence may contribute to some instances of responding to lures in a manner analogous to some descriptions of the misinformation effect in the cognitive literature. At the recognition test, experimental participants were significantly more likely to respond to lure patterns as old (63%) than control participants (11%). The high rate of “old” responses to lures, however, did not prevent experimental participants from accurately identifying target patterns (83%) as old. Moreover, the experimental group correctly identified the target patterns as old on a similar percentage of trials as the control participants (89%). Both groups had a very low percentage of “old” responses to the foil (distracter) patterns (8% and 1% respectively). The tendency to respond to both target and lure patterns as old at the recognition test by the experimental group is consistent with patterns of responding demonstrated in cognitive research on the misinformation effect (e.g., Eakin, Schreiber, & Sergeant-Marshall, 2003). However, the high rate of “old” responses to the target patterns indicates that the effect seen in this study is not due to either

forgetting or interference with recognition of the original stimulus.

### *Methodological Issues*

In an experiment involving similar stimuli presented as targets, lures, and foils, some minor effects of familiarity, generalization, and partial stimulus control are to be expected. Of importance is that these effects are minimized and measurable, and contrast significantly with the misinformation effect due to emergent relations. All of the foil patterns used in this experiment contained at least one component from the target patterns. During Phase 1 training, participants learned that foil patterns could contain a component from the target pattern, and they were trained to respond “new” to patterns that did not contain all the correct components in the proper configuration. The Phase 1 constructed-response task and recognition tests also ensured that participants attended to all the dimensions upon which the patterns could vary: the color and shape of each component, and the configuration of the pattern. This strategy succeeded in keeping responses to foils very low.

For both groups, it was expected that lures would be somewhat more difficult to discriminate from targets than foils as they varied from target patterns on only one dimension in one component (the color of one of the internal components). However, the results from the control group demonstrate that the target and lure patterns were sufficiently discriminable for the task.

The experimental group also showed a slight increase in “old” responses to foils (8%) relative to the control group (1%), a nonsignificant trend also seen across the earlier series of unpublished studies (Challies, 2005). On examination of these responses, it was found that the effect was due to Foils 2 and 6 (see Figure 2) attracting a few more “old” responses than other foils. Foils 2 and 6 happen to share a color combination with Lure 3. It is possible that the slightly greater percentage of “old” responses by the experimental group to the foils is due to familiarity with that color combination because it was established during the Phase 2 MTS training, was not shared with any of the target patterns, and was not experienced by the control group. In spite of this, experimental group responses

to lures (68%) display a significant contrast with their responses to foils (8%). Thus, in this experiment, the small effects of familiarity contrast significantly with the misinformation effect due to emergent relations.

#### *Emergent Relations and Semantic Relations*

The results of this experiment support the findings of Guinther and Dougher (2010) that in some instances derived relations are a behavioral analog to semantic relatedness in the cognitive psychology literature. The results of this experiment also extend the relationship between emergent relations and “false memory” to the postevent misinformation effect. Emergent relations that develop subsequent to a target event have the potential to alter recognition of elements of that event. Cognitive researchers (Hannigan & Tippens Reinitz, 2001; Loftus & Palmer, 1974; Loftus & Zanni, 1975) have demonstrated the enhancement of the misinformation effect when “semantic construal” allows a foreign element to enter into a person’s remembered account of an event, as compared to simple familiarity with the same foreign element. This experiment demonstrates that emergent relations may function as semantic construal in a behavioral analog of the misinformation effect. It should be stressed that there are likely to be a wide variety of causes of “false memory,” many of which likely interact with other causes and with individual differences, and that emergent relations may be one of many potential contributing factors to the misinformation effect.

In line with findings in the cognitive psychology literature (Lindsay, 1990; Lindsay, Allen, et al., 2004; Mitchell & Johnson, 2000), it is likely that the misinformation effect is contingent on the degree to which the source of the information is confused between the original event and the novel misinformation. When the source of misinformation is highly discriminable, misinformation is less likely to be incorporated into an account of an event. As noted earlier, source discriminability may arguably be analogous with context in the behavioral literature (Dougher, et al., 2002; Meehan & Fields, 1995; Randall & Remington, 2006; Rehfeldt, 2003). In the present study, there was likely little discriminability between the original source (the Phase 1 task), and the source of the misinformation (the Phase 2 task). Both of the tasks were delivered in a similar context—a “memory” study conducted in

a computer laboratory by the same experimenter, with similar stimuli and peripheral details. It is possible that manipulating the context within which original and misinformation stimuli are presented may impact on the strength of the misinformation effect—more discriminable contexts may increase the likelihood of participants correctly responding “new” to the lure patterns.

The procedures used to investigate emergent relations as the source of misinformation in the present study may be compared to misinformation research in the cognitive literature. Participants in the present study were given up to 30 min (inclusive of briefing times) to memorize the original stimuli, had repeated viewings, constructed the pattern from its components, and were tested to ensure memory for all key components of the target patterns before proceeding to the misinformation phase of the study. In contrast, initial exposure to the target event in typical misinformation studies is usually very brief, as researchers attempt to re-create real-life experiences (Memon, Hope, & Bull, 2003). Standard misinformation studies may expose participants to a target slide or photograph once for a matter of seconds (Lindsay, Allen, et al., 2004; Memon, et al., 2003; Vornik, Sharman, & Garry, 2003), have participants view a video once only (Kneller, Memon, & Stevenage, 2001; Searcy et al., 2000; Sutherland & Hayne, 2001) or listen to a narrative once only (Chandler et al., 2001). Many misinformation studies in the cognitive literature therefore rely on the target event being poorly observed and/or learned, with laboratory findings then applied in forensic settings (Wells et al., 2000). In spite of extensive exposure to the target stimuli, and a 100% test criterion for progression to Phase 2, the present study demonstrated a robust misinformation effect due to emergent relations in conditions of contextual similarity. This highlights the potential vulnerability of delayed recognition, in a real-world situation, to postevent misinformation from emergent relations.

#### *Suggestions for Future Research*

Colored geometric shapes had been selected for simplicity and utility in constructing patterns. Although they proved adequate for the task, there were differences in responding (for both groups) to different patterns noted across the series, with Target Pattern 2 and Lure 2 attracting fewer “old” responses. Differences in responding across patterns (which

affected both experimental and control groups) may have reflected common prior learning histories for some participants (e.g., some elements may have been more familiar). Future research could norm patterns for familiarity and select patterns with common levels of familiarity.

Research on compound stimuli has shown that emergent relations may be reliably demonstrated following go/no-go procedures without the requirement for MTS training (Debert, Huziware, Faggiani, De Mathis, & McIlvane, 2009; Debert, Matos, & McIlvane, 2007). It is possible that the memorization task itself established equivalence relations between the three stimuli comprising the target pattern. If this were the case, the lure stimulus need only have been trained to one of the original stimuli without the requirement for MTS training of the remaining baseline relations. For the present study, an important consideration was to optimize the conditions under which contextual confusion might occur; this included incorporating the other elements of the pattern into the MTS task, even though only one of them was actually trained to the lure stimulus. Having established that emergent relations do underlie some manifestations of the misinformation effect, future research could investigate the phenomenon using non-MTS procedures.

A further research direction is suggested by the wide variation in time spent on-task by the experimental group during the Phase 2 MTS task. Although there was no relationship between the percentage of correct responses to lures and the time spent acquiring the MTS task, it did become apparent across this and the prior series of unpublished studies (Challies, 2005) that some participants were using a variety of verbal and subvocal strategies. This raised the possibility that verbal strategies may have had an impact on time taken to complete the MTS task. Participants in this study were not given any advice at all on how to associate the stimuli in the MTS classes, and those who vocalized strategies, or appeared to be using subvocal strategies, did so with varying degrees of success. Consequently, those who used a strategy are not distinguishable from those who didn't, either by time or by the number of test phases needed to acquire the task. Research in progress is investigating the impact of instructing participants to use an efficient verbal rule to acquire the MTS task. One question addressed in this research is whether the strategy used impacts

the transfer of function or changes the discriminability of the context.

In summary, the present study provides further support to the thesis that even when initial recognition of elements of a target event is excellent, contextual confusion between classes of stimuli pertaining to the target event, including those formed subsequently, may allow false recognition of elements associated with the target event by emergent relations. Further, stimulus equivalence and emergent relations have the potential to allow a behavioral-experimental investigation of cognitive constructs which have traditionally been largely confined to the cognitive literature. In this account of false memories, they are seen as a by-product of stimulus equivalence and emergent relations. The same learning mechanisms that allow for efficient categorization of novel stimuli within existing equivalence classes are also responsible for some instances of the misinformation effect. Some false memories are therefore not a sign of pathology or deficiency, but are a normal part of human behavior.

## REFERENCES

- Allen, B. P., & Lindsay, D. S. (1998). Amalgamations of memories: Intrusion of information from one event into reports of another. *Applied Cognitive Psychology*, 12, 277-285.
- Arntzen, E. (2004). Probability of equivalence formation: Familiar stimuli and training sequence. *The Psychological Record*, 54, 275-291.
- Belli, R. F. (1989). Influences of misleading postevent information: Misinformation interference and acceptance. *Journal of Experimental Psychology: General*, 118(1), 72-85.
- Challies, D. M. (2005). Stimulus Equivalence and False Memory. Unpublished dissertation, Victoria University of Wellington, Wellington.
- Chandler, C. C., Gargano, G. J., & Holt, B. C. (2001). Witnessing postevents does not change memory traces, but can affect their retrieval. *Applied Cognitive Psychology*, 15, 3-22.
- Debert, P., Huziware, E. M., Faggiani, R. B., De Mathis, M. E. S., & McIlvane, W. J. (2009). Emergent conditional relations in a go/no-go procedure: Figure-ground and stimulus-position compound relations. *Journal of the Experimental Analysis of Behavior*, 92(2), 233-243.
- Debert, P., Matos, M. A., & McIlvane, W. J. (2007). Conditional relations with compound abstract stimuli using a go/no-go procedure. *Journal of the Experimental Analysis of Behavior*, 87(1), 89-96.
- De Rose, J. C., De Souza, D. G., & Hanna, E. S. (1996). Teaching reading and spelling: Exclusion and stimulus equivalence. *Journal of Applied Behavior Analysis*, 29, 451-469.

- Dougher, M. J. (1998). Stimulus equivalence and the untrained acquisition of stimulus functions. *Behavior Therapy*, 29, 577–591.
- Dougher, M. J., & Markham, M. R. (1996). Stimulus classes and the untrained acquisition of stimulus functions. In T. R. Zentall, & P. M. Smeets (Eds.), *Stimulus class formation in humans and animals* (pp. 137–152). Amsterdam: Elsevier Science B.V.
- Dougher, M. J., Perkins, D. R., Greenway, D., Koons, A., & Chiasson, C. (2002). Contextual control of equivalence-based transformation of functions. *Journal of the Experimental Analysis of Behavior*, 78(1), 63–93.
- Dube, W. V., McDonald, S. J., McIlvane, W. J., & MacKay, H. A. (1991). Constructed-response matching to sample and spelling instruction. *Journal of Applied Behavior Analysis*, 24, 305–317.
- Eakin, D. K., Schreiber, T. A., & Sargent-Marshall, S. (2003). Misinformation effects in eyewitness memory: The presence and absence of memory impairment as a function of warning and misinformation accessibility. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 29(5), 813–825.
- Ferrari, C., de Rose, J. C., & McIlvane, W. J. (1993). Exclusion vs. selection training of auditory-visual conditional relations. *Journal of Experimental Child Psychology*, 56, 49–63.
- Ferrari, C., De Rose, J. C., & McIlvane, W. J. (2008). A comparison of exclusion and trial-and-error procedures: primary and secondary effects. *Experimental Analysis of Human Behavior Bulletin*, 29, 9–16.
- Gerrie, M. P., Belcher, L. E., & Garry, M. (2006). 'Mind the gap': false memories for missing aspects of an event. *Applied Cognitive Psychology*, 20(5), 689–696.
- Gross, S. R., Jacoby, K., Matheson, D. J., Montgomery, N., & Patil, S. (2005). Exonerations in the United States 1989 through 2003. *The Journal of Criminal Law & Criminology*, 95(2), <http://law-journals-books.vlex.com/vid/in-the-united-states-through-55615176>.
- Guinther, P. M., & Dougher, M. J. (2010). Semantic false memories in the form of derived relational intrusions following training. *Journal of the Experimental Analysis of Behavior*, 93(3), 329–347.
- Hannigan, S. L., & Tappan, R. (2001). A demonstration and comparison of two types of inference-based memory errors. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 27(4), 931–940.
- Harper, D. N., & Garry, M. (2000). Postevent cues bias recognition performance in pigeons. *Animal Learning & Behavior*, 28(1), 59–67.
- Henkel, L. A., Franklin, N., & Johnson, M. K. (2000). Cross-modal source monitoring confusions between perceived and imagined events. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 26(2), 321–335.
- Horne, P. J., & Lowe, C. F. (1996). On the origins of naming and other symbolic behavior. *Journal of the Experimental Analysis of Behavior*, 65, 185–241.
- Jenkins, J. J., Wald, J., & Pittenger, J. B. (1986). Apprehending pictorial events. In V. McCabe, & G. J. Balzano (Eds.), *Event cognition: An ecological perspective* (pp. 117–133). Hillsdale, NJ: Erlbaum.
- Kneller, W., Memon, A., & Stevenage, S. (2001). Simultaneous and sequential lineups: Decision processes of accurate and inaccurate eyewitnesses. *Applied Cognitive Psychology*, 15, 659–671.
- Lindsay, D. S. (1990). Misleading suggestions can impair eyewitnesses' ability to remember event details. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 16(6), 1077–1083.
- Lindsay, D. S., Allen, B. P., Chan, J. C. K., & Dahl, L. C. (2004). Eyewitness suggestibility and source similarity: Intrusions of details from one event into memory reports of another event. *Journal of Memory and Language*, 50, 96–111.
- Lindsay, D. S., Hagen, L., Wade, K. A., & Garry, M. (2004). True photographs and false memories. *Psychological Science*, 15, 149–154.
- Loftus, E. F. (1975). Leading questions and the eyewitness report. *Cognitive Psychology*, 7, 560–572.
- Loftus, E. F. (1979). The malleability of human memory. *American Scientist*, 67, 312–320.
- Loftus, E. F., & Hoffman, H. G. (1989). Misinformation and memory: The creation of new memories. *Journal of Experimental Psychology: General*, 118(1), 100–104.
- Loftus, E. F., Miller, D. G., & Burns, H. J. (1978). Semantic integration of verbal information into a visual memory. *Journal of Experimental Psychology: Human Learning and Memory*, 4(1), 19–31.
- Loftus, E. F., & Palmer, J. C. (1974). Reconstruction of automobile destruction: An example of the interaction between language and memory. *Journal of Verbal Learning and Verbal Behavior*, 13, 585–589.
- Loftus, E. F., & Zanni, G. (1975). Eyewitness testimony: The influence of the wording of a question. *Bulletin of the Psychonomic Society*, 5(1), 86–88.
- Lyle, K. B., & Johnson, M. K. (2006). Importing perceived features into false memories. *Memory*, 14(2), 197–213.
- Marche, T. A., Brainerd, C. J., & Reyna, V. F. (2010). Distinguishing true from false memories in forensic contexts: Can phenomenology tell us what is real? *Applied Cognitive Psychology*, 24(8), 1168–1182.
- Meehan, E. F., & Fields, L. (1995). Contextual control of new equivalence classes. *The Psychological Record*, 45, 165–182.
- Meeter, M., Shohamy, D., & Myers, C. E. (2009). Acquired equivalence changes stimulus representations. *Journal of the Experimental Analysis of Behavior*, 91(1), 127–141.
- Memon, A., Hope, L., & Bull, R. (2003). Exposure duration: Effects on eyewitness accuracy and confidence. *British Journal of Psychology*, 94, 339–354.
- Mitchell, K. J., & Johnson, M. K. (2000). Source monitoring: Attributing mental experiences. In E. Tulving, & F. I. M. Craik (Eds.), *The Oxford handbook of memory* (pp. 179–195). New York: Oxford University Press.
- Mitchell, K. J., & Zaragoza, M. (1996). Repeated exposure to suggestion and false memory: The role of contextual variability. *Journal of Memory and Language*, 35, 246–260.
- Mitchell, K. J., & Zaragoza, M. (2001). Contextual overlap and eyewitness suggestibility. *Memory & Cognition*, 29(4), 616–626.
- Okado, Y., & Stark, C. E. L. (2005). Neural activity during encoding predicts false memories created by misinformation. *Learning & Memory*, 12(1), 3–11.
- Randell, T., & Remington, B. (2006). Equivalence relations, contextual control, and naming. *Journal of the Experimental Analysis of Behavior*, 86(3), 337–354.
- Rehfeldt, R. A. (2003). Establishing contextual control over generalized equivalence relations. *The Psychological Record*, 53, 415–428.
- Rehfeldt, R. A., & Hayes, L. J. (1998). The operant-responder distinction revisited: toward an understanding of stimulus equivalence. *The Psychological Record*, 48(2), 187–210.

Roediger III, H. L., & McDermott, K. B. (1995). Creating false memories: Remembering words not presented in lists. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 21, 802–814.

Searcy, J., Bartlett, J. C., & Memon, A. (2000). Influence of post-event narratives, line-up conditions and individual differences on false identification by young and older eyewitnesses. *Legal and Criminological Psychology*, 5, 219–235.

Sidman, M. (1994). *Equivalence relations and behavior: A research story*. Boston, MA: Authors Cooperative.

Sidman, M., & Tailby, W. (1982). Conditional discrimination vs. matching to sample: An expansion of the testing paradigm. *Journal of the Experimental Analysis of Behavior*, 37(1), 5–22.

Skagerberg, E. M., & Wright, D. B. (2008). The co-witness misinformation effect: Memory blends or memory compliance? *Memory*, 16(4), 436–442.

Stark, C. E. L., Okado, Y., & Loftus, E. F. (2010). Imaging the reconstruction of true and false memories using sensory reactivation and the misinformation paradigms. *Learning & Memory*, 17(10), 485–488.

Sutherland, R., & Hayne, H. (2001). The effect of postevent information on adults' eyewitness reports. *Applied Cognitive Psychology*, 15, 249–263.

Tonneau, F. (2001). Equivalence relations: A critical analysis. *European Journal of Behavior Analysis*, 2(1), 1–33.

Vornik, L. A., Sharman, S. J., & Garry, M. (2003). The power of the spoken word: Sociolinguistic cues influence the misinformation effect. *Memory*, 11(1), 101–109.

Wells, G. L., Malpass, R. S., Lindsay, R. C. L., Fisher, R. P., Turtle, J. W., & Fulero, S. M. (2000). From the lab to the police station: A successful application of eyewitness research. *American Psychologist*, 55(6), 581–598.

Wirth, O., & Chase, P. N. (2002). Stability of functional equivalence and stimulus equivalence: Effects of baseline reversals. *Journal of the Experimental Analysis of Behavior*, 77(1), 29–47.

Wright, D. B., & Loftus, E. F. (1998). How misinformation alters memories. *Journal of Experimental Child Psychology*, 71, 155–164.

Wright, D. B., Self, G., & Justice, C. (2000). Memory conformity: Exploring misinformation effects when presented by another person. *British Journal of Psychology*, 91, 189–202.

Yamamoto, J., & Asano, T. (1995). Stimulus equivalence in a chimpanzee (*Pan troglodytes*). *The Psychological Record*, 45, 3–21.

Received: April 29, 2011  
Final Acceptance: August 9, 2011

APPENDIX A

Summary of Individual Data for Control Task Group

Number of attempts at each test block (see Table 1) to achieve 100% criterion for progression to next training block.					
Participant	B-A Symmetry	C-A Symmetry	B-C/C-B Transitivity	D-B Symmetry	D-A/A-D/D-C/C-D Transitivity
a100782	2	2	2	2	3
a1984	1	2	2	1	1
ad260287	1	1	1	1	2
CA020787	1	1	1	2	2
dl240887	1	1	1	1	2
dt050565	1	1	5	1	6
ed090884	1	1	4	2	2
HT021084	1	1	1	1	2
ja061086	1	1	2	2	6
KB1987	1	1	1	4	7
LM310783	1	1	2	1	2
mb191185	1	1	1	2	3
me190886	2	1	1	1	1
mh120786	1	1	1	2	2
mk281184	1	1	1	1	3
ms020587	1	1	1	1	1
nk050984	1	1	2	1	4
ns080686	1	1	2	1	3
PD200686	1	1	1	2	6
pf220684	1	1	1	2	2
SM110685	1	1	2	1	2
sp170286	1	3	1	4	4
Unk1	1	1	2	3	6
YW030583	1	1	4	2	3
Mean	1.08	1.17	1.75	1.71	3.13
MS160976*	1	2	2	6	3 (block abandoned)
sr120287*	1	3	14 (block abandoned)		

\*These two participants did not finish the MTS task within the time allocated for the session and were removed from analysis.

APPENDIX A  
(Extended)

Number of attempts at each test block (see Table 1) to achieve 100% criterion for progression to next training block.		Final test score (selection of class members of set A, B, and C respectively given the letter for each set)			Phase 3 recognition test “old” responses		
Total Test Blocks	Time taken (Min.S)				Target	Lure	Foil
11	12.02	3/3	3/3	3/3	3	2	1
7	8.12	3/3	3/3	3/3	3	3	1
6	4.01	3/3	3/3	3/3	3	3	2
7	8.32	3/3	3/3	3/3	2	2	0
6	5.19	3/3	3/3	3/3	3	2	1
14	13.13	3/3	3/3	3/3	3	3	0
10	8.00	2/3	3/3	3/3	3	1	0
6	4.59	3/3	3/3	3/3	2	1	1
12	12.45	3/3	3/3	3/3	2	2	1
14	19.17	3/3	3/3	3/3	2	1	0
7	6.00	3/3	3/3	3/3	2	3	0
8	5.56	3/3	3/3	3/3	2	2	0
6	4.07	3/3	3/3	3/3	3	1	0
7	10.49	3/3	2/3	3/3	3	1	0
7	8.32	3/3	3/3	3/3	2	1	1
5	4.25	3/3	3/3	3/3	2	3	1
9	17.22	3/3	2/3	3/3	3	3	0
8	9.36	3/3	3/3	3/3	3	1	0
11	14.20	3/3	3/3	3/3	2	2	1
7	9.08	3/3	3/3	3/3	3	2	0
7	6.04	3/3	3/3	3/3	2	1	1
13	13.44	3/3	3/3	3/3	3	3	0
13	20.17	3/3	3/3	3/3	1	1	0
11	11.10	3/3	3/3	3/3	3	1	0
—	—	—	—	—	—	—	—

APPENDIX B  
Summary of Individual Data for  
Control Task Group

Participant	Phase 3 recognition test 'old' responses		
	Target	Lure	Foils
a290376	3	0	0
a15031974	2	1	1
a8352	3	0	0
AB070785	3	0	0
AG091188	3	0	0
AJR14/07/87	3	1	0
AK161085	3	0	0
CJ090888	3	1	0
CS031006	3	0	0
DCLXVI	3	0	0
ej140987	3	0	0
ek180288	2	1	0
GZ861010	2	2	0
HM170189	3	0	0
JH13101987	3	0	0
kr050587	3	0	0
me180386	3	0	0
ns050288	1	1	0
Rencee'	3	0	0
SA831127	3	0	0
SC080188	3	0	0
sr	1	1	0
ss130988	2	0	0
SW240687	3	0	0